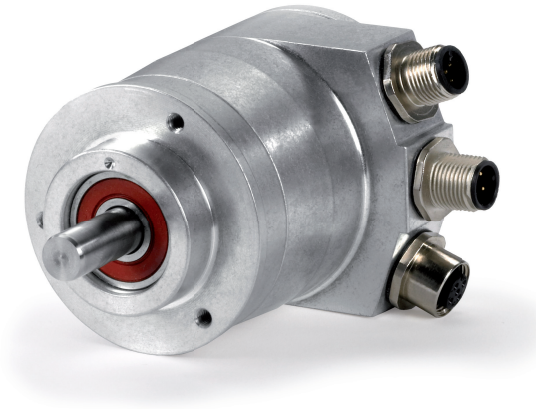
HEIDENHAIN



User's Manual

PROFIBUS-DP

Interface for Encoders

English (en)
7/2014

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1 General information

This manual describes the installation procedures and configuration of HEIDENHAIN absolute encoders and encoder gateways with PROFIBUS DPV0 functionality.

1.1 Encoder gateway

The advantages of the gateway concept is that it allows the use of small and very robust EnDat encoders, which make the encoder gateway solution suitable in applications where very high ambient temperature is a limiting factor.
Another benefit with the gateway solution is that in case of an encoder error occurs, the EnDat encoder can easily be replaced without the need to disconnect the PROFIBUS line. The encoder gateway supports singleturn encoders with up to 31 bit resolution and multiturn encoders with up to 37 bits resolution with the limitations described in this manual.

1.2 Absolute encoders

With an absolute encoder each angular position is assigned a coded position value generated by a code disc equipped with several parallel fine graduations tracks which are scanned individually. On singleturn encoders, i.e. an encoder producing absolute positions within one revolution, the absolute position information repeats itself with every revolution. So called multiturn encoders can also distinguish between revolutions. The numbers of unique revolutions is determined by the resolution of the multiturn scanning and repeats itself after the total resolution is reached.

1.3 PROFIBUS technology

PROFIBUS is a powerful and versatile 2-wire non-proprietary open field bus standard defined by several international standards such as EN 50170, IEC 61158 together with different device profiles. There are 3 different PROFIBUS versions available today, DP, FMS and PA. HEIDENHAIN products support the Decentralized Peripherals (DP) version. In addition to manufacturer-specific functions, the HEIDENHAIN devices described in this manual supports class 1 and 2 according to the encoder profile 3.062. The encoder device profile describing encoder functionality and additional information about PROFIBUS can be ordered from PROFIBUS User Organization, PNO.

PROFIBUS User Organization
Haid-und-Neu Straße 7
D 76131 Karlsruhe, Germany
Tel: +49 721 96 58 590
Fax: + 49 721 96 58 589
Web: www.profibus.com

1.3.1 PROFIBUS DP functionality levels

The main functions of the different levels are as follows:

DPV0: Supports the basic functionality for the PROFIBUS protocol. In principal this means the cyclical I/O communication and diagnostics. This manual only covers DPV0 functionality.

DPV1: The most important benefits with DPV1 are the expanded functions for the acyclical data communication and alarm handling. This is a precondition for parameterization and calibration of field devices over the bus in runtime. HEIDENHAIN have a separate manual for DPV1/DPV2 devices.

DPV2: In addition to the functionality above, DPV2 includes expansions that are required for time critical applications such as motion control. This means functions such as slave-to-slave communications and isochronous data exchange (time synchronization). HEIDENHAIN have a separate manual for DPV1/DPV2 devices.

1.3.2 References

Profile Encoder V1.1, Order No. 3.062

1.3.3 Abbreviations

PROFIBUS	**Pro**cess **Fi**eld **Bus**
PI	**P**ROFIBUS and Profinet International
PNO	**P**ROFIBUS **N**utzer**o**rganisation e.V.
GSD	German term "Gerätestammdaten". A GSD is the device database file, also called device datasheet.
DP	**D**ecentral **P**eriphery
Input data	Data which the master receives from the encoder
Output data	Data which the encoder receives from the master.
PDU	**P**rotocol **D**ata **U**nit
DDLM	**D**irect **D**ata **L**ink **M**apper, the interface between PROFIBUS-DP functions and the encoder software
DDLM_Set_Prm	Interface during parameterization
DDLM_Data_Exchange	Interface during data exchange
DDLM_Slave_Diag	Interface during diagnostics data transfer
DDLM_Chk_Cfg	Interface during configuration

2 Encoder gateway installation

2.1 Settings inside the gateway

The encoder gateway addressing switches and bus termination must be configured during commissioning of the device. This is done by removing the back cover, i.e. screwing off the three screws at the rear of the gateway.

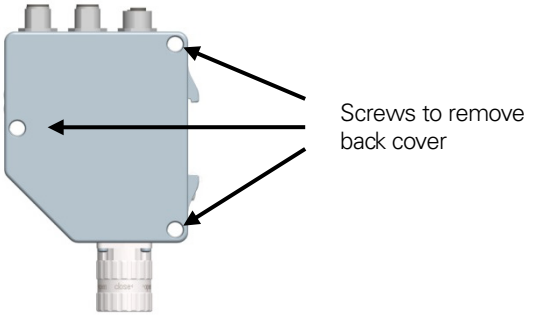


Figure 1 Placement of screws

2.1.1 Node address

The node address of the encoder gateway can be set via three decimal rotary switches located inside the back cover. The weighting, x100, x10 and x1 are specified on the circuit board besides the switches. Permissible address range is between 0 and 126 but the lower addresses 0 to 2 are usually used by the master and not recommended to be used by the device. Each address used in a PROFIBUS network must be unique and may not be used by other devices.

The device address is only read and adopted when the gateway power supply is switched on. A restart of the gateway is therefore required in order to adopt changes done to the address settings.

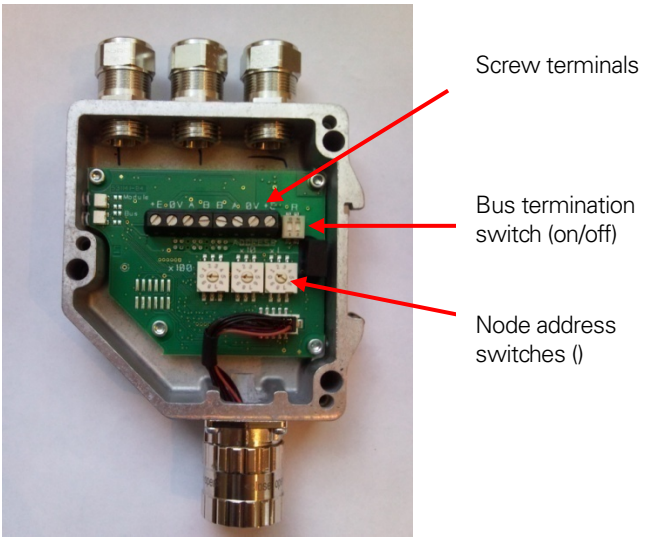


Figure 2 PCB-view of a cable gland PROFIBUS gateway

Example: To set the node address to 115, the switch to the left (x100) shall be set to 1, the switch in the middle(x10) should also be set to 1 and the switch to the right(x1) shall be set to 5.

2.1.2 Bus termination

In a PROFIBUS net, all devices are connected in a bus structure. Up to 32 devices (master and/or slaves) can be connected in one segment. When more devices are needed repeaters should be used to amplify the signals between segments. An active termination must be added in the beginning and the end of each bus segment in order to ensure error-free operation. In case of the gateway with cable glands such terminators are integrated inside the back cover and can be activated via dip switches as shown in figure 2. If the device is un-powered the A and B lines are internally terminated by a 220 Ω resistor.

Bit1	Bit2	Effect
On	On	There is a 220 ohms resistor between bus A and bus B line.
On	Off	Not a valid setting
Off	On	Not a valid setting
Off	Off	There is no resistor between bus A and bus B line.

Table 1 Termination switch settings

When encoder gateways with M12 connectors are used the termination should be done using a M12 terminating resistor plug.

Note: When M12 terminating resistor plugs are used, the internal terminating switch shall not be activated.

2.2 Power supply

The power supply connection of M12 equipped gateways are constituted by a male A-coded 4 pin M12 connector.

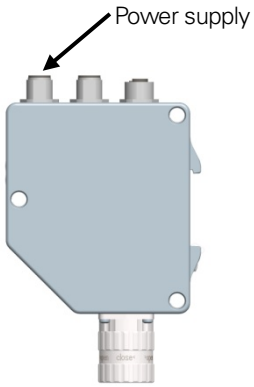


Figure 3 Orientation of M12 power supply connector

Power supply M12 version	
Function	Pin
+E Volt	1
Not connected	2
0 Volt	3
Not connected	4

Table 2 Pinning M12 power supply connector

Encoder gateways equipped with cable glands are delivered with a dust protection foil from the factory. The protection foil needs to be removed prior to installing the cables.
It is recommended that gateways equipped with cable glands are equipped with a shielded power supply cable with conductor area between 0,34 mm^2 to 1.5 mm^2. Permissible outer cable diameter is ø 6 mm to ø 8 mm for the power supply cable. The power supply screw terminal is located inside the back cover of the gateway.
In the case were the gateway is the last node in the bus-structure and only the cable glands for Supply and Bus-in is in use, the Bus out cable gland should be replaced with a M16 filler plug to ensure proper sealing.

The +E terminal shall be used to connect +E Volt.
The 0 V terminal shall be used to connect 0 Volt.

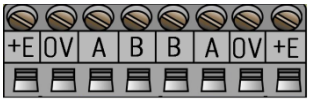


Figure 4 Terminal connections of power supply cables

Note: Tighten all screws in the terminal, even if no cable has been attached.

Note: The two +E terminals are connected to each other and the two 0 V terminals are also connected to each other, i.e it does not matter to which pair the +E Volt and 0 Volt are connected to.

2.3 BUS lines

The PROFIBUS bus line connections of the M12 equipped devices are constituted by a male B-coded 5 pin M12 connector (bus in), and a female B-coded 5 pin M12 connector (bus out).

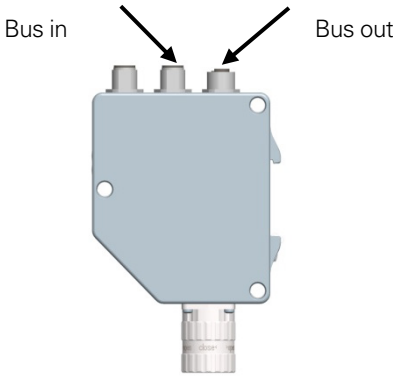


Figure 5 Orientation of M12 bus connectors

Bus in line		**Bus out line**	
Function	Pin	Function	Pin
Not connected	1	VP	1
A	2	A	2
Not connected	3	DGND	3
B	4	B	4
Chassis	5	Chassis	5

Table 3 Pinning M12 bus in/out connectors

The cable gland gateway shall be equipped with twisted pair shielded cable in accordance with EN 50170 and PROFIBUS guidelines. The guidelines recommend a conductor area higher than 0,34 mm^2. Permissible outer cable diameter is ø 8 mm to ø 10 mm for the bus lines cables. Located inside the back cover are four screw terminals containing the required bus line terminals marked A and B. Cable glands not used, should be replaced with a M16 filler plug to ensure proper sealing.

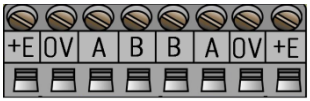


Figure 6 Terminal connections of bus line cables

Note: Tighten all screws in the terminal, even if no cable has been attached.

Note: The two A terminals are internally connected to each other and the two B terminals are also connected to each other so it does not matter to which the bus lines are connected to.

2.4 Shielding philosophy

To achieve the highest possible noise immunity and resistance against other EMI related disturbances the bus and power supply cables shall always be shielded. The screen should be connected to ground on both ends of the cable. In certain cases compensation current might flow over the screen. Therefore a potential compensation wire is recommended.

2.5 GSD file

PROFIBUS Gateways can be configured and parameterized corresponding to the requirements of the user. When the system is started, the PROFIBUS devices are set and configured in DDLM_Set_Prm mode, i.e the application class set by means of the GSD file in the configuration tool and the operating parameters are transferred to the respective slave.

Available GSD files can be downloaded from www.heidenhain.com

GSD file	
Gateway functionality	GSD file
Gateway PROFIBUS DPV0 (For rotary encoders)	ENC_A400

Table 4 Available GSD file for DPV0 gateway

When configuring the gateways two device classes (Class 1 or Class 2) can be selected as described in chapter 4. Selectable parameters and functionality of the device depend on the selected encoder class. This data, saved in the PROFIBUS master is transferred once to the gateway when the system is powered on. If the gateway has been started with one GSD file and a new GSD file with a different ID-number shall be used, the gateway needs to be restarted before it can use the new GSD file.

After the configuration and parameter data have been received, the gateway enters normal operation with cyclic data transfer i.e. “DDLM_Data_Exchange mode”.

Installation of GSD-files:

1) Select and save the GSD file for the respective device from www.heidenhain.com and then copy the *.gsd file into the respective directory of the PROFIBUS configuration tool.

2) Select the bitmap file of the respective device and copy the *.bmp file into the respective directory of the PROFIBUS configuration tool.

3) Update the GSD files (SCAN).

2.6 LED indication

In order to determine the status of the gateway two LEDs are visible on the front of the gateway. The module LED indicates status of the module itself. The bus LED indicates the status of the bus. The table below defines the diagnostic messages using a bi-colored red/green LED for bus and module.

Bus status	Module	Meaning	Cause
Off	Off	No power	
Red	Green	No connection to other device. Criteria: No data exchange	- Bus disconnected - Master not available/switched off
Red[2)]	Red[2)]	No connection to other device. No connection between EnDat encoder and PROFIBUS PCB.	No connection to EnDat encoder at power up.
Blinking[1)]	Green	Parameterization or configuration fault	- Configuration received differs from the supported configuration. - Parameter error in the parameterization.
Green	Red	System failure	- Diagnosis exists, slave in data exchange mode.
Green	Green	Data exchange and encoder function properly.	

Table 5 LED indication

1) The **blinking** frequency is 0.5 Hz. Minimal indication time is 3 sec.
2) Position error is when an alarm occurs in the encoder or if the EnDat encoder is disconnected from the PROFIBUS interface PCB.

3 Absolute encoder installation

3.1 Settings inside the encoder

The encoder node address and bus termination must be configured during commissioning of the device. This is done by removing the back cover, i.e. screwing off the three screws at the rear of the encoder.

3.1.1 Node address

The node address of the encoder can be set via two decimal rotary switches located inside the back cover. The weighting, x10 or x1 are specified beside the switches. Permissible address range is between 0 and 99 but the lower addresses 0 to 2 are usually used by the master and not recommended to be used by the device. Each address used in a PROFIBUS network must be unique and may not be used by other devices.

The device address is only read and adopted when the encoder power supply is switched on. A restart of the encoder is therefore required in order to adopt changes done to the address settings.

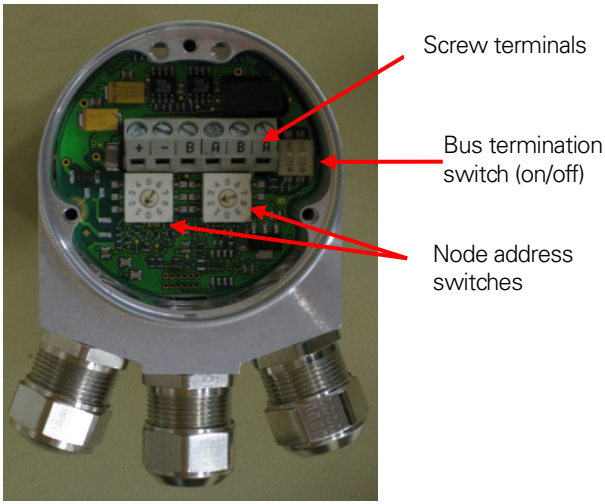


Figure 7 PCB-view of a cable gland encoder

Example: If the node address shall be set to 85, the left (x10) switch shall be set to 8 and the right (x1) switch shall be set to 5.

3.1.2 Bus termination

In a PROFIBUS net, all devices are connected in a bus structure. Up to 32 devices (master and/or slaves) can be connected in one segment. When more devices are needed repeaters should be used to amplify the signals between segments. An active termination must be added in the beginning and end of each bus segment in order to ensure error-free operation.
In case of the encoder with cable glands such terminators are integrated inside the back cover and can be activated via dip switches as shown in figure 7. If the device is un-powered the A and B lines are internally terminated by a 220 Ω resistor.

Bit1	Bit2	Effect
On	On	There is a 220 ohms resistor between bus A and bus B line.
On	Off	Not a valid setting
Off	On	Not a valid setting
Off	Off	There is no resistor between bus A and bus B line.

Table 6 Terminating switch settings

When encoders with M12 connectors are used the termination should be done using a terminating resistor plug.

Note: When encoders with M12 terminating resistor plugs are used, the internal terminating switch shall not be activated.

3.2 Connecting the encoder

The power supply connection of M12 equipped encoders are constituted by a male A-coded 4 pin M12 connector.

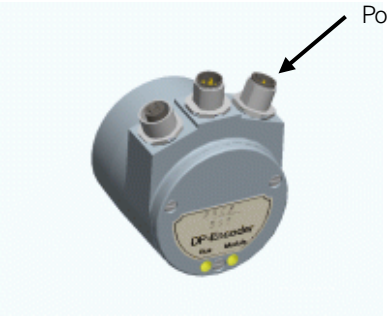


Figure 8 Orientation of M12 power supply connector

Power supply M12 version	
Function	Pin
+E Volt	1
Not connected	2
0 Volt	3
Not connected	4

Table 7 Pinning M12 power supply connector

Encoders equipped with cable glands are delivered with a dust protection foil from the factory. The protection foil needs to be removed prior to install the cables.
It is recommended that encoders with cable gland are equipped with a shielded power supply cable with conductor area between 0,34 mm^2 to 1.5 mm^2. Permissible outer cable diameter is ø 6 mm to ø 8 mm for the power supply cable. Located inside the back cover are two screw terminals containing the required power supply terminals marked (+) and (-). In the case were the encoder is the last node in the bus-structure and only the cable glands for Supply and Bus-in is in use, the Bus out cable gland should be replaced with a M16 filler plug to ensure proper sealing.

The (+) terminal shall be used to connect the +EV-line.
The (-) terminal shall be used to connect the 0 V-line.

Figure 9 Terminal connections of power supply cables

Note: Tighten all screws in the terminal, even if no cable has been attached.

3.2.1 Bus lines

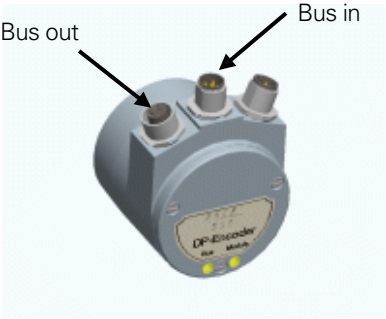


Figure 10 Orientation of M12 bus connectors

Bus in line		**Bus out line**	
Function	Pin	Function	Pin
Not connected	1	VP	1
A	2	A	2
Not connected	3	DGND	3
B	4	B	4
Chassis	5	Chassis	5

Table 8 Pinning M12 bus in/out lines

The cable gland encoders shall be equipped with twisted pair shielded cable in accordance with EN 50170 and PROFIBUS guidelines. The guidelines recommend a conductor area higher than 0,34 mm^2. Permissible outer cable diameter is ø 8 mm to ø 10 mm for the bus line cables. Located inside the back cover are four screw terminals containing the required bus line terminals marked (A) and (B). Cable glands not used should be replaced with a M16 filler plug to ensure proper sealing.

The (A) terminal shall be used to connect the A-line.
The (B) terminal shall be used to connect the B-line.

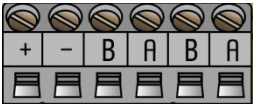


Figure 11 Terminal connections of bus line cables

Note: Tighten all screws in the terminal, even if no cable has been attached.

Note: The two A terminals are internally connected to each other and the two B terminals are also connected to each other so it does not matter to which terminal the bus lines are connected to.

3.3 Shielding philosophy

To achieve the highest possible noise immunity and resistance against other EMI related disturbances the bus and power supply cables shall always be shielded. The screen should be connected to ground on both ends of the cable. In certain cases compensation current might flow over the screen. Therefore a potential compensation wire is recommended.

3.4 GSD file

Absolute encoders with PROFIBUS can be configured and parameterized corresponding to the requirements of the user. When the system is started, the PROFIBUS devices are set and configured in DDLM_Set_Prm mode, i.e. the encoder class set by means of the GSD file in the configuration tool and the operating parameters are transferred to the respective slave.

Available GSD files can be downloaded from www.heidenhain.com.

GSD file	
Gateway functionality	GSD file
Absolute encoder PROFIBUS DPV0	Enc_A401

Table 9 Available GSD file for DPV0 encoders

The GSD data is saved in the PROFIBUS master and transferred once to the encoder when the system is powered on. If the encoder has been started with one GSD file and a new GSD file with a different ID-number shall be used, the encoder needs to be restarted before it can use the new GSD file.

After the configuration and parameter data have been received, the gateway enters normal operation with cyclic data transfer i.e. “DDLM_Data_Exchange mode”.

Installation of GSD-files:

1) Select and save the GSD file for the respective device from www.heidenhain.com and then copy the *.gsd file into the respective directory of the PROFIBUS configuration tool.

2) Select the bitmap file of the respective device and copy the *.bmp file into the respective directory of the PROFIBUS configuration tool.

3) Update the GSD files (SCAN).

3.5 LED indication

In order to determine the status of the encoder two LEDs are visible from the rear end of the encoder. The module LED indicates status of the module itself. The bus LED indicates the status of the bus. The table below defines the diagnostic messages using a red (BUS) and a bicolor, Red/Green, LED (MODULE).

Bus status	Module	Meaning	Cause
Off	Off	No power	
Red	Green	No connection to other device. Criteria :No data exchange	- Bus disconnected - Master not available/ switched off
Red[2)]	Red[2)]	No connection to other device. No connection between EnDat encoder and PROFIBUS PCB.	No connection to EnDat encoder at power up.
Blinking[1)]	Green	Parameterization or configuration fault	- Configuration received differs from the supported configuration. - Parameter error in the parameterization.
Green	Red	System failure	- Diagnosis exists, slave in data exchange mode. - Position error
Green	Green	Data exchange. Slave and operation OK	

Table 10 LED indication encoder

1) The **blinking** frequency is 0.5 Hz. Minimal indication time is 3 sec.
2) Position error is when an alarm occurs in the encoder or if the EnDat encoder is disconnected from the PROFIBUS interface PCB.

4 Profile overview, DPV0 version 1.1.

The operating function in this profile is divided into two device classes named Class 1 and Class 2. Class 1 encoders offer basic functions that all PROFIBUS-DP encoders must support. Encoders of Class 2 must support all functions of Class 1 as well as the additional functionality of Class 2. In addition to the two classes, parameters and diagnostic ranges are reserved for manufacturer-specific functions.

For further information regarding the encoder functionality refer to the device profile. The profile and PROFIBUS technical information can be ordered from www.profibus.com.

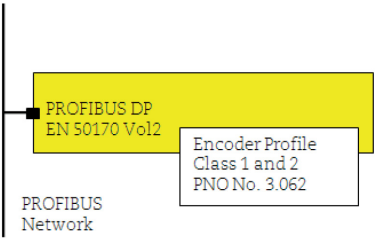


Figure 12 Overview encoder profile and related documents

4.1 DPV0 encoder classes

The device can be configured as a class 1 or class 2 PROFIBUS slave device. Class 2 configuration is extended to optionally access velocity information from the encoder.

CLASS 1
In the CLASS 1 configuration, only input data are assigned. Depending on the encoder resolution, this is one input data word (16 bits) or two (32 bits).

The following functions can be performed:
1) Changed direction of counting (Code sequence)
2) Diagnostic data up to octet 16

Configuration data:
Singleturn Class 1 – 16 Bit: D0hex, 1 input data word, data consistency

Multiturn Class 1 – 32 Bit: D1hex, 2 input data words, data consistency

CLASS 2
In the CLASS 2 configuration output data values and input data words are transferred. Depending on the encoder resolution, this is one input data word (16 bits) and one output data word (16 bits) or two input data words (32 bits) and two output data words (32 bits).

The following functions are available in addition to the class 1 functions:
1) Scaling function
2) Preset Value Function
3) Velocity read-out
4) Extended diagnostic data

Configuration data:
Singleturn Class 2 – 16 bits: F0hex, 1 input data word, 1 output data word for preset value,data consistency

Multiturn Class 2 – 32 bits: F1hex, 2 input data word, 2 output data words for preset value,data consistency

Position + Velocity, Class 2 – 32+16 bits: F1+D0hex, 3 input data word, 2 output velocity data words Velocity for preset value, data consistency

The selection of class depends on the demands required by the application but for enabling full functionality of the device it is recommended to choose: Encoder class 2 32 bit + velocity.

5 Encoder and Gateway functionality, DPV0

5.1 Basic functionality

The picture below gives an overview of the basic encoder and gateway functions and how the functionality is conducted within the device.

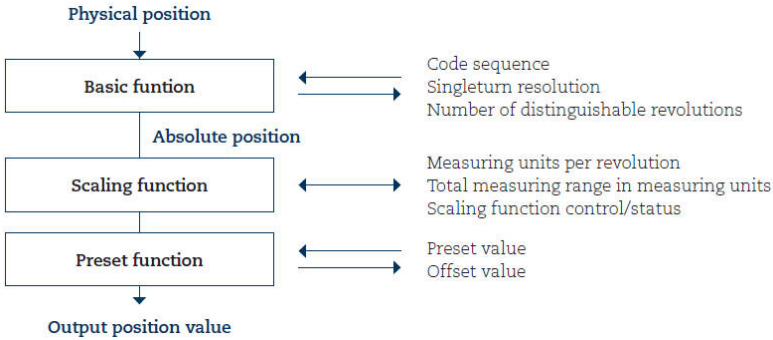


Figure 13 Basic functionality

5.2 PROFIBUS data transfer principle

The PROFIBUS-DP devices can be configured and parameters can be set according to the user's needs.
In this context it is useful to know that with PROFIBUS there are different types of data transmission.

5.2.1 During Configuration (DDLM_Chk_Cfg mode)

The configuration function allows the DP-Master to send the configuration data to the DP-device for checking. The main purpose is to define the number of bytes used for Data_Exchange function.

5.2.2 During Parameterization (DDLM_Set_Prm mode)

When the system is started, the PROFIBUS devices are parameterized (DDLM_Set_Prm mode), i.e. the encoder class set by means of the GSD file in the configuration tool) and the set operating parameters are transferred to the respective slave.

5.2.3 Normal operation (DDLM_Data_Exchange mode)

In the normal mode (DDLM_Data_Exchange mode), data are exchanged between master and slaves. The preset function can be carried out only in this operating mode. The data exchange is described in chapter 5.5.

5.3 Configuration, DPV0

The configuration of a DPV0 device is conducted by choosing encoder class, i.e. setting the input/output data structure. The configuration options are 16-bit, 32-bit or 32-bit + 16-bit velocity input data, for explanation view chapter 4.1.

5.4 Parameterization, DPV0

The PROFIBUS-DPV0 device is parameterized by means of the operating parameters. The values selected in the configuration tool are saved in the DP master and are transferred to the PROFIBUS-DP slave each time the network is started. The following table lists all available parameters:

Parameters	Data type	Parameter octet number	Device class
Code sequence	Bit	9	1
Class 2 functionality	Bit	9	2
Commissioning diagnostics	Bit	9	Optional
Scaling function control	Bit	9	2
Measuring units per revolution	Unsigned 32 bits	10-13	2
Total measuring range in measuring units	Unsigned 32 bits	14-17	2
Manufacturer specific functions	Bit	26-28	Optional
Velocity control	2 bit	39	2.ext

Table 11 Operating parameters in DPV0

Octet	9
Bits	7-0
Data	2^7-2^0
	Operating parameters

Bits	Definition	=0	=1
0	Code sequence	Clockwise (CW) Increasing position values when rotated clockwise (seen from flange side)	Counter clockwise (CCW) Increasing position values when rotated counter clockwise (seen from flange side)
1	Class 2 functionality	Disable	Enable
2	Commissioning diagnostics	No	Yes
3	Scaling function control	Disable scaling	Enable scaling. Scaling parameters are taken into octets 10 to 17.
4	Reserved		
...			
7			

Table 12 Octet 9, Parameter definition

5.4.1 Code sequence

The code sequence defines whether the absolute position value should increase during clockwise or counter clockwise rotation of the encoder shaft seen fromflange side. The code sequence is by default set to increase the absolute position value when the shaft is turned clockwise (0).

Note: The position value will be affected when the code sequence is changed during operation. It might be necessary to perform a preset after the code sequence has been changed.

5.4.2 Class 2 functionality

This bit enables or disables class 2 functionality. The Class 2 functionality bit for PROFIBUS-DP devices is by default disabled (0). This means that this control bit must be activated during parameterization in order to support the class 2 functions.

Note: If a class 1 device uses some optional class 2 functions, the class 2 control bit must be set.

5.4.3 Commissioning diagnostics

The commissioning diagnostics function makes enable the device to perform internal diagnostic test of the encoder components responsible for position detection during a standstill of the encoder (i.e. light unit, photovoltaic cells etc.). In conjunction with the position alarms, it enables thorough checking of whether the position values provided by the absolute encoder are correct. The commissioning diagnostics function is started by the commissioning bit in the operating parameters. If an error is found within the absolute encoder, this is indicated in the diagnostic function by the commissioning diagnostics alarm bit (see chapter 5.6.2).
The commissioning diagnostics function is an option. To find out whether the device supports commissioning diagnostics, the "operating status" should be read by the diagnostic function and the commissioning diagnostics bit should be checked.

5.4.4 Scaling function control

The scaling function converts the encoder's physical absolute position value by means of software in order to change the resolution of the encoder. Class 2 functionality must be enabled in order to use the scaling function. The parameters "Measuring units per revolution" and "Total measuring range in measuring steps" are the scaling parameters set by the parameter function in octet 10 to 17. Scaling is active only if the control bit for the scaling function is set. When the scaling function control bit is set to 0, the scaling function is disabled.

Singleturn encoders up to 31 bit and multiturn encoders up to 37 bits resolution are supported by the PROFIBUS gateway. When using encoders with higher resolution than 31 bits, the singleturn resolution of the encoder will automatically be reduced as much as needed to fit into the 32 bit structure.

For example, if a 37 bit encoder with a 25 bit singleturn and 12 bit multiturn resolution is used, the singleturn resolution will be reduced from 25 to 19 bit, and the multiturn resolution will still be 12 bit. (19 bit singleturn+12 bit multiturn = 31 bit total resolution).

Note: After downloading new scaling parameters the Preset function must be used to set the encoder starting point to absolute position 0 or to any required starting position within the scaled operating range.

5.4.5 Measuring units per revolution

The total measuring range is calculated by multiplying the singleturn resolution with the number of distinguishable revolutions.

The default settings for singleturn encoders are:
Measuring units per revolution= 8192 (2^{13})
Total measuring range in measuring units= 8192 ($2^{13} \times 2^{0}$)

The default settings for 25 bit multiturn encoders are:
Measuring units per revolution= 8192 (2^{13})
Total measuring range in measuring units= 33554432 ($2^{13} \times 2^{12}$)

Format of the scaling parameters:

Octet	10	11	12	13
Bits	31-24	23-16	15-8	7-0
Data	2^{31}-2^{24}	2^{23}-2^{16}	2^{15}-2^{8}	2^{7}-2^{0}
	Measuring units per revolution			

Table 13 Singleturn scaling parameters format

Octet	10	11	12	13
Bits	31-24	23-16	15-8	7-0
Data	2^{31}-2^{24}	2^{23}-2^{16}	2^{15}-2^{8}	2^{7}-2^{0}
	Measuring units per revolution			

Table 14 Multiturn scaling parameters format

The data format for both scaling parameters is 32 bits without sign, with a value range from 2^0 to 2^{31}. The permissible value range is limited by the resolution of the encoder. For a 25-bit encoder with a singleturn resolution of 13 bits the permissible value range for "Measuring units per revolution" is between 2^0 and 2^{13} (8192) and for the "Total measuring range in measuring steps" the permissible value range is between 2^0 and 2^{25} (33554432). The scaling parameters are securely stored in the PROFIBUS-DP master and are reloaded into the encoder at each power-up. Both parameters are output data in 32-bit format.

Example of scaling and entry:
If the user wants to scale the encoder to a single turn resolution of 4000 unique positions per revolution and a total number of turn count equal to 3200 revolutions shall the configuration be as:

Measuring units per revolution = 4000 steps

Total measuring range in measuring units
= 4000 steps x 3200 revolutions
= 12800000

Entry in the master configuration software:
Measuring units per revolution = 4000
Total measuring range (steps) = 12800000

5.4.6 Total measuring range (units)

The total measuring range is defined by the parameter "Total measuring range in measuring units." The device has two different operating modes, depending on the specified measuring range. When the device receives a parameter message, it checks the scaling parameters if a binary scaling can be used. If binary scaling can be used, the device selects operating mode A (see following explanation). If not, operating mode B is selected.

A. Cyclic operation (Binary scaling)
Cyclic operation is used when operating with 2^x number of turns (2, 4, 8, 16, 32, 64, 128, 256, 512, 1024, 2048. 4096.. number of turns). If the desired total measuring range is equal to the specified single turn resolution * 2^x (where x<= 12) the encoder operates in endless cyclic operation (0 - max - 0 -max..). If the position value increases above the maximum value by rotating the encoder shaft, the encoder continues from 0.

Example of a cyclic scaling:
Total measuring range = Measuring units per revolution x number of revolutions

Measuring units per revolution = 1000
Total measuring range = 32000 (2^5 = number of revolution 32)

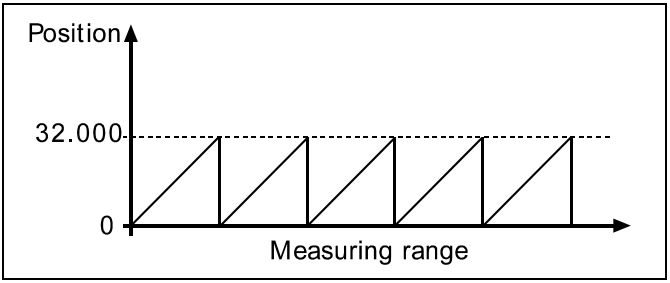


Figure 14 Cyclic scaling

B. Non-cyclic scaling
If the measuring range is used to limit the encoder value range to a value not equal to the specified singleturn resolution * 2^X, the output position value is limited within the operating range. If the position value increases or decreases outside the measuring range by rotating the encoder shaft beyond the maximum value or below 0, the device outputs the total measuring range value.

Example of non-cyclic scaling:

Measuring units per revolution = 100
Total measuring range = 5000 (number of revolutions 50)

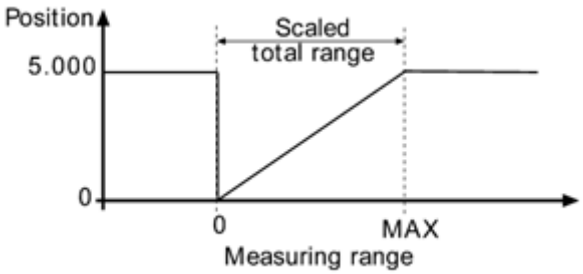


Figure 15 Non-cyclic scaling

5.4.7 Velocity control

The velocity data can be accessed if
class 2 32-bit + velocity configuration is used. In this case the input data consists of 32-position data plus 16-bit signed velocity data. The input velocity value is negative in CCW direction if code sequence is set to CW. If the measured velocity is higher then what is possible to present with the selected velocity unit the value is set to 0x7FFF (32768) or 0x8000 (-32768) depending on direction of shaft rotation.

Note: If the velocity control function is used and scaling is set to the device the velocity calculation is based on the scaled position value. Consequently the accuracy of the velocity value is dependent of the scaling set to the device.

5.4.8 Velocity calculation

The velocity calculations are made with a maximum of 19 bits resolution. If the resolution is higher than 2^{19}, the value used for velocity calculations is automatically reduced to 2^{19}. For a multiturn encoder with 2^{12} multiturn resolution, the maximum singleturn value will be 2^{19} and the velocity will be calculated on the same resolution as presented in the diagnostic structure. For a singleturn encoder the resolution can be up to 31 bit, but the velocity calculations will be made on maximum 19 bits. This means that in the diagnostic structure, the value 2^{31} can be presented, but the resolution used for velocity calculations is not presented if the singleturn resolution is higher than 2^{19}.

The parameter for velocity unit, octet 39 can be seen below:

Octet	**39**
Bits	7-0
Data	2^7-2^0
	Velocity control

Bit	**7**	**6**	**5**	**4**	**3**	**2**	**1**	**0**	**Velocity unit**
			0	0					Steps/s
			0	1					Steps/100 ms
			1	0					Steps/10 ms
			1	1					RPM (revolutions per minute)

Table 15 Octet 39, Velocity Control

In case of steps/s unit, an average is made over 200 ms, and the value is multiplied by 5.

5.5 Data transfer in normal operation (DDLM_Data_Exchange)

The DDLM_Data_Exchange mode is the normal status of the device when operated. In this mode the position value is transmitted from the device in a cyclic manner. Output data can also be sent to the device i.e. preset commands.

5.5.1 Data exchange mode

The actual position value is transferred to the master as 32-bit values (double word) or optional, the device supports a position value length of 16-bit for singleturn encoder. The position value is right-aligned in the data field.

DDLM_Data_Exchange mode

Standard configuration:

Octet	**1**	**2**	**3**	**4**
Bits	31-24	23-16	15-8	7-0
Data	2^{31}-2^{24}	2^{23}-2^{16}	2^{15}-2^{8}	2^{7}-2^{0}
	Data_Exchange -32 bits			

Table 16 Data exchange -32-bits

Configuration data:

Device class 1: D1hex 2 input data words, data consistency

Device class 2: F1hex 2 input data words, 2 output data words for preset value, data consistency

Octet	1	2
Bits	15-8	7-0
Data	2^{15}-2^{8}	2^{7}-2^{0}
	Data_Exchange -16 bits	

Table 17 Data exchange -16 bits

Configuration data:

Device class 1: D0hex 1 input data word, data consistency

Device class 2: F0hex 1 input data word, 1 output data word for preset value, data consistency

5.5.2 Preset function

The preset function enables adaptation of the position value from the encoder to a known mechanical reference point of the system. The preset function sets the actual position of the encoder to zero or to the selected preset value. The preset value is written to the encoder as output data in the Data_Exchange function. If scaling is used the preset function shall be used after the scaling function, to ensure that the preset value is entered in the current measuring unit. The most significant bit (MSB) of the preset value controls the preset function as follows:

Normal operating mode: MSB = 0 (bit 31, optionally bit 15) The encoder will not change the preset value.

Activated mode: MSB = 1 (bit 31, optionally bit 15) With MSB = 1, the encoder accepts the transferred value (bits 0 – 30) as a preset value in binary code. The encoder reads the current position value and calculates an offset value from the preset value and the read position value. The position value is shifted by the calculated offset value. If the input position value equals the preset value, the preset mode is terminated and the MSB can be set to 0 by the master. The offset value can be read with the diagnostic function and is securely stored in case of a power interruption and is reloaded at each start-up.

Note: The preset function should only be used at encoder standstill.

Preset value format (2 words, 32 bits)

Octet	1		2	3	4
Bits	31	30-24	23-16	15-8	7-0
Data	0/1	2^{30}-2^{24}	2^{23}-2^{16}	2^{15}-2^{8}	2^{7}-2^{0}
	Preset control bit	Preset value – Max. 31 bits			

Table 18 Preset value, 32-bit format

Preset value format (1 words, 16 bits)

Octet	1		2
Bits	15	14-8	7-0
Data	0/1	2^{14}-2^{8}	2^{7}-2^{0}
	Preset control bit	Preset value – Max.15 bits	

Table 19 Preset value, 16-bit format

5.6 Diagnostics

The diagnostic information contains diagnostic data which are defined in the PROFIBUS-DP specification (octets 1 to 6) but also encoder specific diagnostic data:

DDLM_Slave_Diag

Diagnostic function	Data type	Diagnostic Octet number	Device class
Station status 1	Bits	1	1
Station status 2	Bits	2	1
Station status 3	Bits	3	1
Diagnostics master address	Bits	4	1
PNO identification number	Bits	5-6	1
Extended diagnostic header	Octet string	7	1
Alarms	Octet string	8	1
Operating status	Octet string	9	1
Encoder type	Octet string	10	1
Singleturn resolution(encoder) Measuring unit (linear encoder)	32 without sign	11-14	1
Number of distinguishable revolutions	16 without sign	15-16	1
Additional alarms	Octet string	17	2
Supported alarms	Octet string	18-19	2
Warnings	Octet string	20-21	2
Supported warnings	Octet string	22-23	2
Profile version	Octet string	24-25	2

Diagnostic function	Data type	Diagnostic Octet number	Device class
Software version	Octet string	26-27	2
Operating time	32 without sign	28-31	2
Offset value	32 with sign	32-35	2
Manufacturer offset value	32 with sign	36-39	2
Measuring units per revolution	32 without sign	40-43	2
Total measuring range in measuring units	32 without sign	44-47	2
Serial number	ASCII string	48-57	2
Reserved for future		58-61	2

Table 20 Diagnostic message, DPV0

Note: The length of the diagnostic information of class 1 is limited to 16 bytes, compatible with previos DP version. For PROFIBUS-DP encoders of class 2, the length of the encoder specific diagnostic data including the extended diagnostic header is 57 bytes.

5.6.1 Diagnostic Header

The header byte specifies the length of the encoder diagnostics including the header byte. The format of the transmission length is hexadecimal. For the PROFIBUS-DP encoder of class 1 the length of the encoder-specific diagnostic data is 10 bytes (0Ahex).

DDLM_Slave_Diag

Octet	**7**		
Alarms	7	6	5-0
Data	0	0	xxh
	Set to 00		Length incl. header
	Extended diagnosis		

Table 21 Diagnostic header

5.6.2 Alarms

Alarm is generated by the device when failure occurs which effects the position value. Octet 8 in the diagnostic function (DDLM_Slave_Diag) indicates the status of the alarms. Additional alarms for device class 2 are addedin the diagnostic octet 17.
If an alarm is given, the Ext_Diag bit and the Stat_Diag bit in the diagnostic function are set to high and remain high until the alarm is cleared and the encoder can provide a correct position value. Alarms are cleared when the functionality is within the specifi- cation and the position value is correct.

Note: Not every encoder supports every alarm. For encoders of class 2 the diagnostic information "supported alarms" (see Chapter 5.6.8) makes it possible to find out which individual alarm bits are supported.

DDLM_Slave_Diag

Octet	8
Bits	7-0
	Alarms

Bits	Definition	=0	=1
0	Position error	No	Yes
1	Voltage supply error	No	Yes
2	Current is too high	No	Yes
3	Commissioning diagnostics	OK	Error
4	Memory error	No	Yes
5-7	Currently not assign		

Table 22 Alarms

5.6.3 Operating Status

Octet 9 in the diagnostic function provides information about encoder-specific parameters. A class 2 encoder sets the functionality bit for class 2 commands in order to show the DP master that all class 2 commands are supported. The DP master must activate the class 2 functionality bit in the parameter message (DDLM_Set_Prm) to enable the use of class 2 functions. The status bit of the scaling function is set when the scaling function is activated and the resolution of the encoder is calculated by means of the scaling parameters.

DDLM_Slave_Diag

Octet	**9**
Bits	7-0
	Operating status

Bits	**Definition**	**=0**	**=1**
0	Code sequence	Increasing position values for clockwise revolutions (Seen from flange side)	Increasing position values for counter clockwise revolutions (Seen from flange side)
1	Class 2 functionality	No, not supported	Yes
2	Commissioning diagnostics	No, not supported	Yes
3	Scaling function status	Scaling disabled	Scaling enabled
4-7	Currently not assigned		

Table 23 Operating status

5.6.4 Encoder type

The type of encoder can be read in octet 10 of the diagnostic function. The type of encoder is defined in hex-code in the range from 0 to FF.

DDLM_Slave_Diag

Octet	10
Bits	0-FF
	Encoder type

Bits	Definition
00	Absolute singleturn encoder
01	Absolute multiturn encoder
02	Absolute singleturn encoder with electronic revolution counter
03	Incremental rotary encoder
04	Incremental rotary encoder with battery buffer
05	Incremental linear encoder
06	Incremental linear encoder with battery buffer
07	Absolute linear encoder
08	Absolute linear encoder with periodic coding
09-FF	Currently not assigned

Table 24 Diagnostic, encoder

5.6.5 Singleturn resolution or measuring step

The singleturn resolution in the diagnostic function has different meanings depending on the type of encoder.
For rotary or angle encoders, the diagnostic octets 11 to 14 indicate the physical resolution in number of measuring steps per revolution which is transferred for the absolute singleturn position value. The maximum singleturn resolution is 2^{31}. For linear encoders the measuring steps is presented with respect to the resolution of the linear encoder, i.e. each increment of the measuring step is equal the actual resolution for the linear encoder in use. Typical values for the linear resolution are 1µm - 40 µm.

DDLM_Slave_Diag

Octet	11	12	13	14
Bits	31-24	23-16	15-8	7-0
Data	2^{31}-2^{24}	2^{23}-2^{16}	2^{15}-2^{8}	2^{7}-2^{0}
	Singleturn resolution			

Table 25 Diagnostic, singleturn resolution

5.6.6 Number of distinguishable revolutions

The number of distinguishable revolutions that the encoder can transfer is defined by octets 15 and 16 of the diagnostic function. In accordance with the formula below, the measuring range for an encoder results from the number of distinguishable revolutions multiplied by the singleturn resolution. The maximum number of distinguishable revolutions is 65536-1(16 bits).
Measuring range = number of distinguishable revolutions x singleturn resolution

DDLM_Slave_Diag

Octet	15	16
Bits	15-8	7-0
	Number of distinguishable revolutions	

Table 26 Diagnostics, number of distinguishable revolutions

5.6.7 Additional alarms

The diagnostic octet 17 indicates additional alarms for device class 2.

Octet	17
Bits	7-0
	Additional alarms

Octet	Definition	=0	=1
Bits	Currently not assigned		
0..7			

Table 27 Diagnostics, additional alarms

5.6.8 Supported alarms

The diagnostics octet 18 and 19 contain information on the supported alarms.

Octet	18	19
Bits	15-8	7-0
	Supported alarms	

Octet	Definition	=0	=1
0	Position error	Not supported	Supported
1	Voltage supply error	Not supported	Supported
2	Current is too high	Not supported	Supported
3	Commissioning diagnostics	Not supported	Supported
4	Memory error	Not supported	Supported
5..15	Currently not assigned		

Table 28 Diagnostics, supported alarms

5.6.9 Warnings

Warnings indicate that tolerances for certain internal parameters of the device have been exceeded. Contrary to alarms, no faulty position values are expected in case of warnings. Octets 20 and 21 of the diagnostic function indicate the status of the warnings. If a warning is set, the Ext_Diag bit in the diagnostic function is logically set to 1 until the warning is cleared. All warnings are deleted when the diagnostic message of the device has been read. However, if the tolerances are still exceeded, the warning is activated again. The warning "Maximum operating time exceeded" (bit 4) is not activated before the system is switched on again.

Note: Not every encoder supports every warning. Please refer to the diagnostic information under "Supported Warnings", see chapter 5.6.10, for information on the support of specific warnings.

Octet	**20**	**21**
Bits	15-8	7-0
	Warnings	

Octet	**Definition**	**=0**	**=1**
0	Frequency exceeded	No	Yes
1	Temperature exceeded	No	Yes
2	Light control reserve	Not reached	Reached
3	CPU monitoring status	OK	Reset
4	Maximum operating time exceeded	No	Yes
5	Battery charging	OK	Too low
6	Reference point	Reached	Not reached
7..15	Currently not assigned		

Table 29 Diagnostics, warnings

5.6.10 Supported warnings

The diagnostics octet 22 and 23 contain information about supported warnings.

Octet	22	23
Bits	15-8	7-0
	Supported Warnings	

Octet	Definition	=0	=1
0	Frequency warning	Not supported	Supported
1	Temperature warning	Not supported	Supported
2	Light control reserve warning	Not supported	Supported
3	CPU monitoring status warning	Not supported	Supported
4	Maximum operating time exceeded warning	Not supported	Supported
5	Battery charging warning	Not supported	Supported
6	Reference point warning	Not supported	Supported
7..15	Currently not assigned		

Table 30 Diagnostics, supported warnings

5.6.11 Profile Version

Octets 24 and 25 of the diagnostic function provide the PROFIBUS-DP encoder profile version that is implemented in the device. The octet's revision number and index are combined.

Example:

Profile version	1.40	
Octet no.	24	25
Binary code.	00000001	01000000
Hex.	1	40

DDLM_Slave_Diag

Octet	**24**	**25**
Bits	15-8	7-0
Data	2^7-2^0	2^7-2^0
	Revision number	Index
	Profile Version	

Table 31 Diagnostics, profile version

5.6.12 Software Version

Octets 26 and 27 of the DDLM_Slave_Diag function provide the software version of the device. The octet's revision number and index are combined.

Example:

Software version	1.40	
Octet no.	26	27
Binary code.	00000001	01000000
Hex.	1	40

DDLM_Slave_Diag

Octet	26	27
Bits	15-8	7-0
Data	2^7-2^0	2^7-2^0
	Revision number	Index
	Software Version	

Table 32 Diagnostics, software version

5.6.13 Operating time

The operating time monitor stores the operating time for the device in operating hours. The operating time is saved every six minutes in the non-volatile memory in the device. This happens as long as the device is under power. The operating time is displayed as a 32-bit value without sign in 0.1 h by the DDLM_Slave_Diag function.If the operating time function is not supported by the device, it is set to the maximum value (FFFF FFFF hex).

DDLM_Slave_Diag

Octet	28	29	30	31
Bits	31-24	23-16	15-8	7-0
Data	2^{31}-2^{24}	2^{23}-2^{16}	2^{15}-2^8	2^7-2^0
	Operating time			

Table 33 Diagnostic, operating time

5.6.14 Offset value

The offset value is calculated by the preset function and shifts the position value by the calculated value.
The offset value is stored in the device and can be provided by the diagnostic octets 32 to 35. The data type for the offset value is a 32-bit binary value with sign, whereby the offset value range is equal to the measuring range of the device. The preset function is used after the scaling function. This means that the offset value is indicated according to the scaled resolution of the device.

DDLM_Slave_Diag

Octet	32	33	34	35
Bits	31-24	23-16	15-8	7-0
Data	2^{31}-2^{24}	2^{23}-2^{16}	2^{15}-2^{8}	2^{7}-2^{0}
	Offset value			

Table 34 Diagnostics, offset value

5.6.15 Offset value of the encoder manufacturer

The manufacturer offset value indicates the encoder offset set by the manufacturer. This value gives information on the shift of the position zero point in number of positions from the physical zero point of the encoder. The data type for the offset value is a 32-bit binary value with sign. The value range corresponds to the measuring range of the encoder. The offset value of the manufacturer of the encoder is indicated in the number of units according to the basic resolution of the encoder. The value is stored in write-protected memory, which can be changed only by the encoder manufacturer. This value has practically no importance for the user.

Octet	36	37	38	39
Bits	31-24	23-16	15-8	7-0
Data	2^{31}-2^{24}	2^{23}-2^{16}	2^{15}-2^{8}	2^{7}-2^{0}
	Offset value of the encoder manufacturer			

Table 35 Diagnostics, offset value of the encoder manufacturer

5.6.16 Scaling parameters settings

The scaling parameters are set in the DDLM_Set_Prm function. The parameters are stored in the octets 40 to 47 of the diagnostic data. The "Measuring units per revolution" and "Total measuring range in measuring units" parameters define the selected resolution of the encoders. The status bit of the scaling function in the operating status (octet 9 of the diagnostic data) indicates whether the scaling function is enabled.

Values preset by the manufacturer of the encoder:
Measuring units per revolution = singleturn resolution.

Total measuring range in measuring units = singleturn resolution x number of distinguishable revolutions.
The data type for both values is unsigned 32 bits.

DDLM_Slave_Diag

Octet	**40**	**41**	**42**	**43**
Bits	31-24	23-16	15-8	7-0
Data	2^{31}-2^{24}	2^{23}-2^{16}	2^{15}-2^{8}	2^{7}-2^{0}
	Measuring units per revolution			

DDLM_Slave_Diag

Octet	**44**	**45**	**46**	**47**
Bits	31-24	23-16	15-8	7-0
Data	2^{31}-2^{24}	2^{23}-2^{16}	2^{15}-2^{8}	2^{7}-2^{0}
	Total measuring range in measuring units			

Table 36 Diagnostics, scaling parameter setting

5.6.17 Encoder serial number

Octet 48 to 57 of the diagnostic function provides the serial number of the encoder as a 10-character ASCII string.

DDLM_Slave_Diag

Octet	**48-57**
Bits	79-0
Data	ASCII
	Serial number

Example of a serial number

Octet	**48**	**49**	**50**	**51**	**52**	**53**	**54**	**55**	**56**	**57**
ASCII string	30	30	30	35	39	46	38	44	45	35
Serial (hex)	0	0	0	5	9	F	8	D	E	5
Serial (Dec)	94342629									

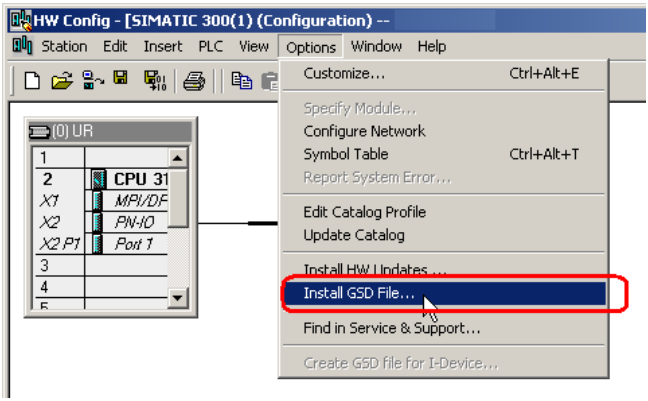
Table 37 Diagnsotics, encoder serial number

6 Encoder commissioning example, DPV0

This example uses a Siemens master software. The example is intended to illustrate the commissioning of a PROFIBUS-DPV0 encoder with a 25 bit absolute rotary encoder and velocity information.

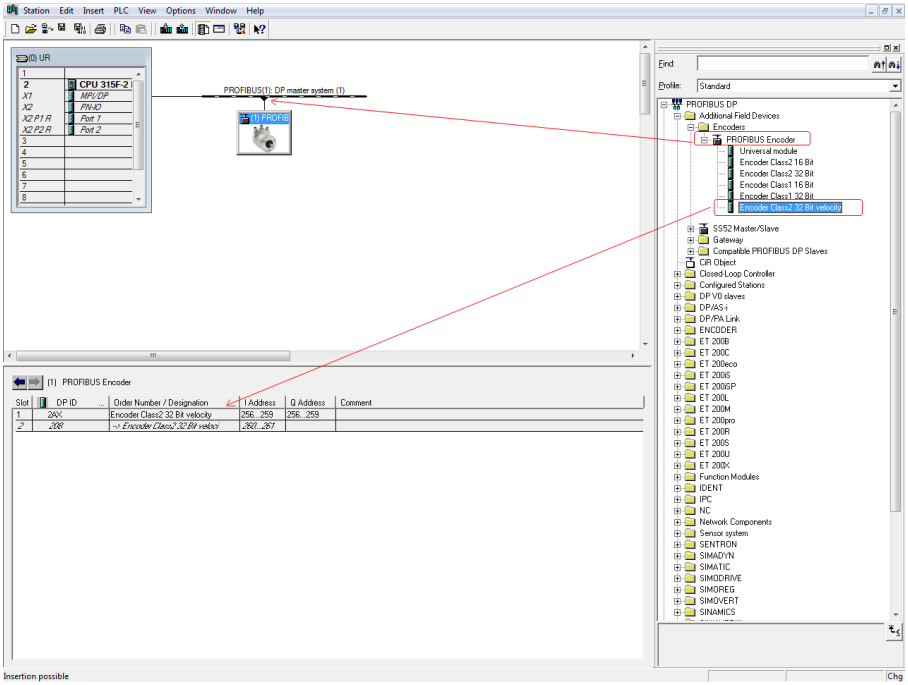
Copying the GSD file

First, copy the GSD file and bitmap file into the corresponding directory in the configuration software,...\GSD. Then install the GSD file into your system.



Selecting the DPV0 Slave

To select the encoder click on the "PROFIBUS Encoder" icon in the map structure on the right side of the window. Use "drag-and-drop" to add the encoder on the BUS, upper left view.



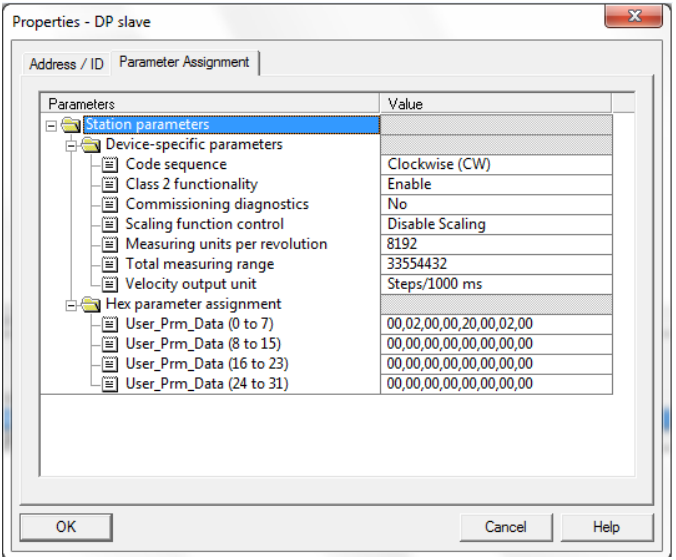
When dropping the encoder on the BUS a PROFIBUS address must be assigned, naturally this address must be the same as assigned on the hardware address switches on the back of the encoder. See chapter 3.1.1.

Configuration of DPV0 Slave

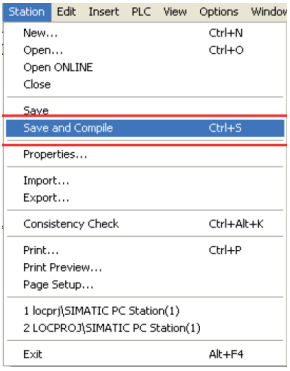
To configure the encoder for 25-bit position value plus velocity data choose the "Encoder Class 2 32-bit velocity" configuration option in the map structure. Add the chosen configuration by "drag-and-drop" to the configuration window in lower left view.

Assigning parameters to the DPV0 slave

By "double-clicking" on the configuration row in the configuration view the parameterization view will be opened.



Add or change the data in the "value" field to the desired parameter values. Chapter 5,4 describes the functionality and possibility of each parameter. Then save and compile the setting by clicking Save and compile on the Station tab.



7 Revision history

Revision	Date	changes
Rev. 1.0	2014-07-01	First release

Table 38 Revision history

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1111895-20 · Ver00 · 7/2014 · PDF